

Related Appeals and Interferences

Appellants assert that no other appeals, interferences or judicial proceedings are known to the Appellants, the Appellants' legal representative or Assignee that will directly affect, be directly affected by or have a bearing on the Board's decision in the pending appeal.

Status of Claims

Claims 1-19 are pending in the application and were originally presented in the application. Claims 1-19 stand rejected under 35 U.S.C. § 102(b) and 35 U.S.C. § 103(a). The rejection of the pending claims is appealed. The pending claims are shown in the attached Appendix A.

Status of Amendments

No amendments have been made to the pending claims.

Summary of the Invention

Conventional polymerization processes generally result in considerable amounts of unreacted monomers and low molecular weight polymers remaining entrained in the copolymer product after the polymerization process. However, the presence of these agents in the final polymer product may have adverse effects on such polymer's properties. Accordingly, removal of these undesirable volatile components is highly desirable. *See*, specification, at least paragraph 2.

One method of removing such agents is extrusion and/or steam stripping. Unfortunately such processes introduce the polymer product to stresses that contribute to undesirable gel formation, among other problems. *See*, specification, at least paragraph 5.

Accordingly, embodiments of the present invention provide a method of manufacturing a polymer including passing a block copolymerization product, such as polystyrene-*block*-butadiene-*block*-polystyrene, through a first devolatilizer operated at a first low pressure to form a once devolatilized copolymer and passing the once

devolatilized block copolymer product from the first devolatilizer to a conduit. *See*, specification, at least paragraph 7.

Issues Presented

1. Whether the Examiner erred in rejecting claims 1-19 under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,143,833 (*Klussman*) on grounds that *Klussman* does not show devolatilizing a block copolymer, as recited in the pending claims.

2. Whether the Examiner erred in rejecting claims 1-19 under 35 U.S.C. §103(a) as being unpatentable over *Klussman* on grounds that *Klussman* does not teach, show or suggest devolatilizing a block copolymer, as recited in the pending claims.

Arguments

I. THE EXAMINER ERRED IN REJECTING CLAIMS 1-19 UNDER 35 U.S.C. §102(B) AS BEING ANTICIPATED BY *KLUSSMAN* BECAUSE *KLUSSMAN* DOES NOT SHOW DEVOLATILIZING A BLOCK COPOLYMER.

Applicants personally interviewed the pending claims with the Examiner on September 28th, 2004, where the Examiner concurred with the Applicants' argument that the process of *Klussman* is not identical to the process as claimed. *See*, Interview Summary dated September 28, 2004. However, the Examiner then issued a Final Rejection on November 17, 2004.

The Final Rejection stated that regarding the claimed block copolymer feature, Applicants must recognize that *Klussman* involves the incorporation of polybutadiene into the disclosed styrene polymerization resulting in a copolymer having blocks of polybutadiene attached. *See*, Final Rejection at page 3, second paragraph.

The terms block copolymer and graft copolymer are terms known to one skilled in the art of polymer science, such definitions being discussed in further detail below.

Applicants disagree that *Klussman* teaches "a copolymer having blocks of polybutadiene attached," as the Examiner asserts. Rather, *Klussman* teaches a copolymer including a polybutadiene backbone, which is NOT a copolymer, having blocks of polystyrene attached, forming a grafted copolymer. *See*, at least column 4, lines 21-40

and column 5, lines 20-21. Such grafted copolymer is shown below, where A denotes polybutadiene and B denotes polystyrene.

AAAAAAAAAAAAA
B
B
B

A graft copolymer is a copolymer composed of graft macromolecules. Graft macromolecules are composed of blocks connected to a main chain as side-chains, these side-chains having constitutional or configurational features that differ from those in the main chain. See, *IUPAC Glossary of Basic Terms in Polymer Science*, 68 Pure Applied Chemistry Journal, 2287 (1996), Definitions 2.23 and 1.28, submitted herewith.

The pending claims recite a block copolymer. A block copolymer is a copolymer composed of block macromolecules. Block macromolecules are composed of blocks in linear sequence. See, *id.*, Definitions 1.26 and 2.22. A non-limiting example of such block copolymer is shown below.

AAAABBBBBBAAAAA

The Examiner further states that a block copolymer means a copolymer having a regular placement of repeating units in a copolymer and whether the copolymer is linear, branched comb-like or ladder-like, as long as the copolymers of *Klussman* are having a regular placement of repeating units in a copolymer, the copolymers of *Klussman* are block copolymers.

Applicants strongly disagree. The Examiner has provided no support for his definition of block copolymer and such definition is inaccurate based on the evidence provided above (*e.g.*, linear sequences of one monomer unit followed by linear sequences of another.) As stated above, the backbone of *Klussman* is not composed of adjacent blocks within a linear chain.

The Examiner further states that the grafted polystyrene block units can also be viewed as part of the main chain, which constitutes a block copolymer in the main chain. See, Final Rejection at page 3, third paragraph.

Applicants strongly disagree. Polybutadiene is not grafted onto a backbone of polybutadiene and polystyrene. However, if the Examiner's position were correct (*e.g.*, that the block copolymer backbone was AAAAABBBBB), the copolymer would not be a

monovinyl aromatic polymer containing grafted polybutadiene, as *Klussman's* claim 1 recites. Again, a graft copolymer includes a side chain having constitutional or configurational features that differ from those in the main chain. The compound suggested by the Examiner and shown below does not meet such a definition.

AAAAAAAAAABBBB

A
A
A
A
A
A

Therefore, reversal of the rejection is respectfully requested.

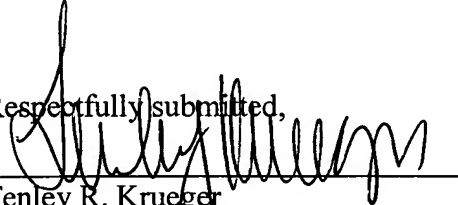
II. THE EXAMINER ERRED IN REJECTING CLAIMS 1-19 UNDER 35 U.S.C. §103(A) AS BEING UNPATENTABLE OVER *KLUSSMAN* BECAUSE *KLUSSMAN* DOES NOT TEACH, SHOW OR SUGGEST DEVOLATILIZING A BLOCK COPOLYMER

The Examiner set forth the same arguments for the §103(a) rejection as the §102(b) rejection. Applicants distinguished *Klussman* from the pending claims in the above discussion and feel that repeating such arguments is unnecessary. Based on such previously presented arguments, Applicants respectfully request reversal of the rejection.

Conclusion

In conclusion, *Klussman* nowhere teaches or suggests devolatilizing a block copolymer, such as recited in the pending claims. Thus, Applicants respectfully request reversal of the rejections of claims 1-19.

Respectfully submitted,


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Appendix A

Claims

1. (Original) A method of manufacturing a polymer comprising:
passing a block copolymerization product through a first devolatilizer operated at a first low pressure to form a once devolatilized copolymer; and
passing said once devolatilized block copolymer product from said first devolatilizer to a conduit.
2. (Original) The method as recited in Claim 1 further including passing said once devolatilized block copolymer product from said conduit into a second devolatilizer to form a twice devolatilized block copolymer.
3. (Original) The method as recited in Claim 2 wherein said first devolatilizer is operated at a lower processing temperature than said second devolatilizer.
4. (Original) The method as recited in Claim 3 wherein said first devolatilizer is operated at a temperature of about 145°F and said second devolatilizer is operated at a temperature of about 300°F.
5. (Original) The method as recited in Claim 2 wherein said second devolatilizer is operated at a second low pressure wherein said second low pressure is less than said first low pressure.
6. (Original) The method as recited in Claim 5 wherein said pressure of said first devolatilizer ranges from about 20 Torr to about 200 Torr and said pressure of said second devolatilizer is equal to or less than about 20 Torr.
7. (Original) The method as recited in Claim 1 wherein said passing includes passing said block copolymerization product comprising:
a monovinyl aromatic homopolymer block;
a conjugated diene block;

a random conjugated diene-monovinyl aromatic rubber block; and
a monovinyl-substituted aromatic homopolymer block.

8. (Original) The method as recited in Claim 1 wherein said passing said once devolatilized block copolymer includes passing to a pelletizer to form an end product.

9. (Original) The method as recited in Claim 8 wherein passing said once devolatilized block includes passing through an extruder prior to passing said once devolatilized block copolymer product to said pelletizer.

10. (Original) The method as recited in Claim 1 wherein said pressure of said first devolatilizer ranges from about 200 Torr to less than about 20 Torr.

11. (Original) The method as recited in Claim 1 wherein said passing said once devolatilized block copolymer maximizes foam formation.

12. (Original) A method of manufacturing a block copolymer comprising:
passing a block copolymerization product through a first devolatilizer operated at a first low temperature to form a once devolatilized block copolymer product;
passing said once devolatilized block copolymer product from said first devolatilizer to a second devolatilizer operated at a second low temperature to form a twice devolatilized block copolymer product.

13. (Original) The method as recited in Claim 12 wherein said first low temperature is less than said second low temperature.

14. (Original) The method as recited in Claim 13 wherein said first low temperature is about 145°F and said second low temperature is about 300°F.

15. (Original) The method as recited in Claim 12 wherein a pressure of said first devolatilizer ranges from about 20 Torr to about 200 Torr and a pressure of said second devolatilizer is equal to or less than about 20 Torr.

16. (Original) The method as recited in Claim 12 wherein said passing includes passing said block copolymerization product, comprising:

- a monovinyl aromatic homopolymer block;
- a conjugated diene block;
- a random conjugated diene-mono-vinyl aromatic rubber block; and
- a monovinyl-substituted aromatic homopolymer block.

17. (Original) The method as recited in Claim 12 wherein said passing said once devolatilized block copolymer includes passing said twice devolatilized block copolymer product to a pelletizer to form an end product.

18. (Original) The method as recited in Claim 17 wherein passing said once devolatilized block copolymer includes passing said twice devolatilized block copolymer product through an extruder prior to passing said twice devolatilized block copolymer product to said pelletizer.

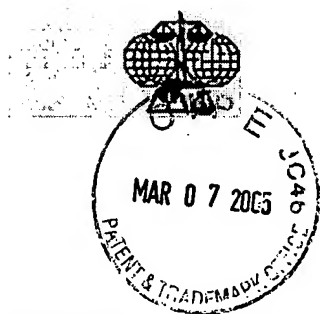
19. (Original) The method as recited in Claim 12 wherein said passing said block copolymer product through said first and second devolatilizers maximizes foam formation.

Appendix B

Evidence

IUPAC Glossary of Basic Terms in Polymer Science, 68 Pure Applied Chemistry Journal, 2287 (1996)

U.S. Patent No. 6,143,833 (*Klussman*)



IUPAC

Pure Appl. Chem., Vol. 68, No.12, pp. 2287-2311, 1996

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Glossary of basic terms in polymer science (IUPAC Recommendations 1996)

Prepared for publication by A. D. Jenkins (UK),
P. Kratochvil (Czech Republic), R. F. T. Stepto
(UK), and U. W. Suter (Switzerland)

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MOLECULES AND MOLECULAR STRUCTURE

1.1 macromolecule

polymer molecule

A molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass.

Notes

1. In many cases, especially for synthetic polymers, a molecule can be regarded as having a high relative molecular mass if the addition or removal of one or a few of the units has a negligible effect on the molecular

properties. This statement fails in the case of certain macromolecules for which the properties may be critically dependent on fine details of the molecular structure.

2. If a part or the whole of the molecule has a high relative molecular mass and essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass, it may be described as either **macromolecular** or **polymeric**, or by **polymer** used adjectivally.

1.2 oligomer molecule

A molecule of intermediate relative molecular mass, the structure of which essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass.

Notes

1. A molecule is regarded as having an intermediate relative molecular mass if it has properties which do vary significantly with the removal of one or a few of the units.

2. If a part or the whole of the molecule has an intermediate relative molecular mass and essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass, it may be described as **oligomeric**, or by **oligomer** used adjectivally.

1.3 monomer molecule

A molecule which can undergo polymerization (see Definition 3.1), thereby contributing constitutional units (see Definition 1.14) to the essential structure of a macromolecule (see Definition 1.1).

1.4 regular macromolecule

A macromolecule (see Definition 1.1), the structure of which essentially comprises the repetition of a single constitutional unit (see Definition 1.14) with all units connected identically with respect to directional sense.

1.5 irregular macromolecule

A macromolecule ([see Definition 1.1](#)), the structure of which essentially comprises the repetition of more than one type of constitutional unit ([see Definition 1.14](#)), or a macromolecule the structure of which comprises constitutional units not all connected identically with respect to directional sense.

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1.6 linear macromolecule

A macromolecule ([see Definition 1.1](#)), the structure of which essentially comprises the multiple repetition in linear sequence of units derived, actually or conceptually, from molecules of low relative molecular mass.

1.7 regular oligomer molecule

An oligomer molecule ([see Definition 1.2](#)), the structure of which essentially comprises the repetition of a single constitutional unit ([see Definition 1.14](#)) with all units connected identically with respect to directional sense.

1.8 monomeric unit

monomer unit

mer

The largest constitutional unit ([see Definition 1.14](#)) contributed by a single monomer molecule ([see Definition 1.3](#)) to the structure of a macromolecule ([see Definition 1.1](#)) or oligomer molecule ([see Definition 1.2](#)).

Note

The largest constitutional unit contributed by a single monomer molecule to the structure of a macromolecule or oligomer molecule may be described as either **monomeric**, or by **monomer** used adjectivally.

1.9 macromonomer molecule

A macromolecule (see [Definition 1.1](#)) that has one end-group which enables it to act as a monomer molecule (see [Definition 1.3](#)), contributing only a single monomeric unit (see [Definition 1.8](#)) to a chain of the final macromolecule.

1.10 macroradical

A macromolecule (see [Definition 1.1](#)) which is also a free radical.

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1.11 pre-polymer molecule

A macromolecule (see [Definition 1.1](#)) or oligomer molecule (see [Definition 1.2](#)) capable of entering, through reactive groups, into further polymerization (see [Definition 3.1](#)), thereby contributing more than one monomeric unit (see [Definition 1.8](#)) to at least one chain of the final macromolecule.

Note

A pre-polymer molecule capable of entering into further polymerization through reactive end-groups (see [Definition 1.35](#)), often deliberately introduced, is known as a **telechelic molecule**.

1.12 macromonomeric unit

macromonomer unit

The largest constitutional unit (see

Definition 1.14) contributed by a single macromonomer molecule (see Definition 1.9) to the structure of a macromolecule (see Definition 1.1).

1.13 degree of polymerization

The number of monomeric units) in a macromolecule (see Definition 1.1) an oligomer molecule (see Definition 1.2), a block (see Definition 1.62), or a chain (see Definition 1.30).

1.14 constitutional unit

An atom or group of atoms (with pendant atoms or groups, if any) comprising a part of the essential structure of a macromolecule (see Definition 1.1), an oligomer molecule (see Definition 1.2), a block (see Definition 1.62), or a chain (see Definition 1.30).

1.15 constitutional repeating unit (CRU)

The smallest constitutional unit (see Definition 1.14), the repetition of which constitutes a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).

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1.16 configurational unit

A constitutional unit (see Definition 1.14) having at least one site of defined stereoisomerism.

1.17 configurational base unit

A constitutional repeating unit (see Definition 1.15) in a regular

macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30), the configuration of which is defined at least at one site of stereoisomerism in the main chain (see Definition 1.34).

1.18 configurational repeating unit

The smallest set of successive configurational base units (see Definition 1.17) that prescribes configurational repetition at one or more sites of stereoisomerism in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).

1.19 stereorepeating unit

A configurational repeating unit (see Definition 1.18) having defined configuration at all sites of stereoisomerism in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).

1.20 tacticity

The orderliness of the succession of configurational repeating units (see Definition 1.18) in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).

1.21 tactic macromolecule

A regular macromolecule ([see Definition 1.4](#)) in which essentially all the configurational (repeating) units ([see Definitions 1.16 and 1.18](#)) are identical.

1.22 stereoregular macromolecule

A regular macromolecule ([see Definition 1.4](#)) essentially comprising only one species of stereorepeating unit ([see Definition 1.19](#)).

1.23 isotactic macromolecule

A tactic macromolecule ([see Definition 1.21](#)), essentially comprising only one species of configurational base unit ([see Definition 1.17](#)), which has chiral or prochiral atoms in the main chain ([see Definition 1.34](#)) in a unique arrangement with respect to its adjacent constitutional units ([see Definition 1.14](#)).

Notes

1. In an isotactic macromolecule, the configurational repeating unit ([see Definition 1.16](#)) is identical with the configurational base unit.
2. An isotactic macromolecule consists of meso diads ([see Definition 1.64](#)).

1.24 syndiotactic macromolecule

A tactic macromolecule ([see Definition 1.21](#)), essentially comprising alternating enantiomeric configurational base units ([see Definition 1.17](#)), which have chiral or prochiral atoms in the main chain

(see [Definition 1.34](#)) in a unique arrangement with respect to their adjacent constitutional units (see [Definition 1.14](#)).

Notes

1. In a syndiotactic macromolecule, the configurational repeating unit consists of two configurational base units that are enantiomeric.
2. A syndiotactic macromolecule consists of racemo diads (see [Definition 1.64](#)).

1.25 atactic macromolecule

A regular macromolecule (see [Definition 1.4](#)) in which the configurational (base) units (see [Definitions 1.16](#) and [1.17](#)) are not all identical.

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1.26 block macromolecule

A macromolecule (see [Definition 1.1](#)) which is composed of blocks (see [Definition 1.62](#)) in linear sequence.

1.27 junction unit

A non-repeating atom or non-repeating group of atoms between blocks in a block macromolecule (see [Definition 1.26](#)).

1.28 graft macromolecule

A macromolecule (see [Definition 1.1](#)) with one or more species of block (see [Definition 1.62](#)) connected to the main chain (see [Definition 1.34](#)) as side-chains (see [Definition 1.53](#)), these side-chains having constitutional or configurational features that differ

from those in the main chain.

1.29 stereoblock macromolecule

A block macromolecule ([see Definition 1.26](#)) composed of stereoregular, and possibly non-stereoregular, blocks ([see Definition 1.62](#)).

1.30 chain

The whole or part of a macromolecule ([see Definition 1.1](#)), an oligomer molecule ([see Definition 1.2](#)), or a block ([see Definition 1.62](#)), comprising a linear or branched sequence of constitutional units ([see Definition 1.14](#)) between two boundary constitutional units, each of which may be either an end-group ([see Definition 1.35](#)), a branch point ([see Definition 1.54](#)), or an otherwise-designated characteristic feature of the macromolecule.

Notes

1. Except in linear single-strand macromolecules ([see Definition 1.39](#)), the definition of a chain may be somewhat arbitrary.
2. A cyclic macromolecule has no end-groups but may nevertheless be regarded as a chain.
3. Any number of branch points may be present between the boundary units.
4. Where appropriate, definitions relating to *macromolecule* may also be applied to *chain*.

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1.31 subchain

An arbitrarily chosen contiguous sequence of constitutional units ([see Definition 1.14](#)) in a chain ([see](#)

Definition 1.30).

Note

The term *subchain* may be used to define designated subsets of the constitutional units in a chain.

1.32 linear chain

A chain (see Definition 1.30) with no branch points (see Definition 1.54) intermediate between the boundary units.

1.33 branched chain

A chain (see Definition 1.30) with at least one branch point (see Definition 1.54) intermediate between the boundary units.

1.34 main chain

backbone

That linear chain (see Definition 1.32) to which all other chains, long (see Definition 1.36) or short (see Definition 1.37) or both, may be regarded as being pendant

Note

Where two or more chains could equally be considered to be the main chain, that one is selected which leads to the simplest representation of the molecule.

1.35 end-group

A constitutional unit (see Definition 1.14) that is an extremity of a macromolecule (see Definition 1.1) or oligomer molecule (see Definition 1.2).

Note

An end-group is attached to only one constitutional unit of a macromolecule or oligomer

molecule.

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1.36 long chain

A chain ([see Definition 1.30](#)) of high relative molecular mass.

Note

See Note 1 to [Definition 1.1](#).

1.37 short chain

A chain ([see Definition 1.30](#)) of low relative molecular mass.

Note

See Note 1 to [Definition 1.2](#).

1.38 single-strand chain

A chain ([see Definition 1.30](#)) that comprises constitutional units ([see Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through two atoms, one on each constitutional unit.

1.39 single-strand macromolecule

A macromolecule ([see Definition 1.1](#)) that comprises constitutional units ([see Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through two atoms, one on each constitutional unit.

1.40 double-strand chain

A chain ([see Definition 1.30](#)) that comprises constitutional units ([see Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through three or four atoms, two on one side and

either one or two on the other side of each constitutional unit.

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1.41 double-strand macromolecule

A macromolecule ([see Definition 1.1](#)) that comprises constitutional units ([see Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through three or four atoms, two on one side and either one or two on the other side of each constitutional unit.

1.42 spiro chain

A double-strand chain ([see Definition 1.40](#)) consisting of an uninterrupted sequence of rings, with adjacent rings having only one atom in common.

Note

A spiro chain is a double-strand chain ([see Definition 1.40](#)) with adjacent constitutional units ([see Definition 1.14](#)) joined to each other through three atoms, two on one side and one on the other side of each constitutional unit.

1.43 spiro macromolecule

A double-strand macromolecule ([see Definition 1.41](#)) consisting of an uninterrupted sequence of rings, with adjacent rings having only one atom in common.

Note

A spiro macromolecule is a double-strand macromolecule ([see Definition 1.41](#)) with adjacent constitutional units ([see Definition 1.14](#)) joined to each other through

three atoms, two on one side and one on the other side of each constitutional unit.

1.44 ladder chain

A double-strand chain ([see Definition 1.40](#)) consisting of an uninterrupted sequence of rings, with adjacent rings having two or more atoms in common.

Note

A ladder chain is a double-strand chain ([see Definition 1.40](#)) with adjacent constitutional units ([see Definition 1.14](#)) joined to each other through four atoms, two on one side and two on the other side of each constitutional unit.

1.45 ladder macromolecule

A double-strand macromolecule ([see Definition 1.41](#)) consisting of an uninterrupted sequence of rings, with adjacent rings having two or more atoms in common.

Note

A ladder macromolecule is a double-strand macromolecule ([see Definition 1.41](#)) with adjacent constitutional units ([see Definition 1.14](#)) joined to each other through four atoms, two on one side and two on the other side of each constitutional unit.

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1.46 multi-strand chain

A chain ([see Definition 1.30](#)) that comprises constitutional units ([see Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through

more than four atoms, more than two on at least one side of each constitutional unit.

Note

A chain that comprises constitutional units joined to each other through n atoms on at least one side of each constitutional unit is termed an **n -strand chain**, e.g., three-strand chain. If an uncertainty exists in defining n , the highest possible number is selected.

1.47 multi-strand macromolecule

A macromolecule (see [Definition 1.1](#)) that comprises constitutional units (see [Definition 1.14](#)) connected in such a way that adjacent constitutional units are joined to each other through more than four atoms, more than two on at least one side of each constitutional unit.

Note

A macromolecule that comprises constitutional units joined to each other through n atoms on at least one side of each constitutional unit is termed an **n -strand macromolecule**, e.g., three-strand macromolecule. If an ambiguity exists in defining n , the highest possible number is selected.

1.48 skeletal structure

The sequence of atoms in the constitutional unit(s) (see [Definition 1.14](#)) of a macromolecule (see [Definition 1.1](#)), an oligomer molecule (see [Definition 1.2](#)), a block (see [Definition 1.62](#)), or a chain (see [Definition 1.30](#)), which defines the essential topological representation.

1.49 skeletal atom

An atom in a skeletal structure (see

Definition 1.48).

1.50 skeletal bond

A bond connecting two skeletal atoms (see Definition 1.49).

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1.51 star macromolecule

A macromolecule (see Definition 1.1) containing a single branch point (see Definition 1.54) from which linear chains (see Definition 1.32) (arms) emanate.

Notes

1. A star macromolecule with n linear chains (arms) attached to the branch point is termed an **n -star macromolecule**, e.g., five-star macromolecule.
2. If the arms of a star macromolecule are identical with respect to constitution and degree of polymerization, the macromolecule is termed a **regular star macromolecule**.
3. If different arms of a star macromolecule are composed of different monomeric units, the macromolecule is termed a **variegated star macromolecule**.

1.52 comb macromolecule

A macromolecule (see Definition 1.1) comprising a main chain (see Definition 1.34) with multiple trifunctional branch points (see Definition 1.54) from each of which a linear side-chain (see Definition 1.53) emanates.

Notes

1. If the subchains between the branch points of the main chain and

the terminal subchains of the main chain are identical with respect to constitution and degree of polymerization, *and* the side chains are identical with respect to constitution and degree of polymerization (see Definition 1.13), the macromolecule is termed a **regular comb macromolecule**.

2. If at least some of the branch points are of functionality greater than three, the macromolecule may be termed a **brush macromolecule**.

1.53 branch

side-chain

pendant chain

An oligomeric (see Definition 1.2) or polymeric (see Definition 1.1) offshoot from a macromolecular (see Definition 1.1) chain (see Definition 1.30).

Notes

1. An oligomeric branch may be termed a **short-chain branch**.
2. A polymeric branch may be termed a **long-chain branch**.

1.54 branch point

A point on a chain (see Definition 1.30) at which a branch (see Definition 1.53) is attached.

Notes

1. A branch point from which f linear chains emanate may be termed an **f -functional branch point**, e.g., five-functional branch point. Alternatively, the terms **trifunctional**, **tetrafunctional**, **pentafunctional**, etc. may be used, e.g., pentafunctional branch point.
2. A branch point in a network may be termed a **junction point**.

1.55 branch unit

A constitutional unit ([see Definition 1.14](#)) containing a branch point ([see Definition 1.54](#)).

Note

A branch unit from which f linear chains emanate may be termed an **f -functional branch unit**, e.g., five-functional branch unit. Alternatively, the terms **trifunctional**, **tetrafunctional**, **pentafunctional**, etc. may be used, e.g., pentafunctional branch unit.

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1.56 pendant group

side-group

An offshoot, neither oligomeric ([see Definition 1.2](#)) nor polymeric ([see Definition 1.1](#)), from a chain ([see Definition 1.30](#)).

1.57 macrocycle

A cyclic macromolecule ([see Definition 1.1](#)) or a macromolecular cyclic portion of a macromolecule.

Notes

1. See Note 2 to [Definition 1.30](#).
2. In the literature, the term *macrocycle* is sometimes used for molecules of low relative molecular mass that would not be considered *macromolecules* as specified in [Definition 1.1](#).

1.58 network

A highly ramified macromolecule ([see Definition 1.1](#)) in which essentially each constitutional unit ([see Definition 1.14](#)) is connected to each other constitutional unit and to the macroscopic phase boundary by

many permanent paths through the macromolecule, the number of such paths increasing with the average number of intervening bonds; the paths must *on the average* be co-extensive with the macromolecule.

Notes

1. Usually, and in all systems that exhibit rubber elasticity, the number of distinct paths is very high, but, in most cases, some constitutional units exist which are connected by a single path only.
2. If the permanent paths through the structure of a network are all formed by covalent bonds, the term **covalent network** may be used.
3. The term **physical network** may be used if the permanent paths through the structure of a network are not all formed by covalent bonds but, at least in part, by physical interactions, such that removal of the interactions leaves individual macromolecules or a macromolecule that is not a network.

1.59 crosslink

A small region in a macromolecule (see Definition 1.1) from which at least four chains (see Definition 1.30) emanate, and formed by reactions involving sites or groups on existing macromolecules or by interactions between existing macromolecules.

Notes

1. The small region may be an atom, a group of atoms, or a number of branch points connected by bonds, groups of atoms, or oligomeric chains.
2. In the majority of cases, a crosslink is a covalent structure but the term is also used to describe sites of weaker chemical interactions, portions of crystallites, and even physical interactions and entanglements.

1.60 micronetwork

A highly ramified macromolecule (see Definition 1.1) that contains cyclic structures and is of colloidal dimensions.

1.61 loose end

A chain (see Definition 1.30), only one point of which is attached to a network (see Definition 1.58).

1.62 block

A portion of a macromolecule (see Definition 1.1), comprising many constitutional units (see Definition 1.14), that has at least one feature which is not present in the adjacent portions.

Note

Where appropriate, definitions relating to *macromolecule* may also be applied to *block*.

1.63 constitutional sequence

The whole or part of a chain (see Definition 1.30) comprising one or more species of constitutional unit(s) (see Definition 1.14) in defined sequence.

Note

Constitutional sequences comprising two constitutional units are termed **diads**, those comprising three constitutional units **triads**, and so on. In order of increasing sequence lengths they are called **tetrads**, **pentads**, **hexads**, **heptads**, **octads**, **nonads**, **decads**, **undecads**, etc.

1.64 configurational sequence

The whole or part of a chain (see Definition 1.30) comprising one or more species of configurational unit (s) (see Definition 1.16) in defined sequence.

Note

Configurational sequences comprising two configurational units are termed **diads**, those with three such configurational units **triads**,

and so on. In order of increasing sequence lengths they are called **tetrads**, **pentads**, **hexads**, **heptads**, **octads**, **nonads**, **decads**, **undecads**, etc.

1.65 polyelectrolyte molecule

A macromolecule (see [Definition 1.1](#)) in which a substantial portion of the constitutional units (see [Definition 1.14](#)) have ionizable or ionic groups, or both.

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1.66 ionomer molecule

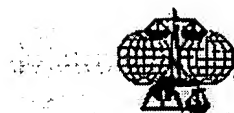
A macromolecule (see [Definition 1.1](#)) in which a small but significant proportion of the constitutional units (see [Definition 1.14](#)) have ionizable or ionic groups, or both.

Note

Some protein molecules may be classified as ionomer molecules

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Glossary of basic terms in polymer science (IUPAC Recommendations 1996)

Prepared for publication by A. D. Jenkins (UK),
P. Kratochvíl (Czech Republic), R. F. T. Stepto
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SUBSTANCES

2.1 monomer

A substance composed of monomer
molecules (see Definition 1.3).

2.2 polymer

A substance composed of
macromolecules (see Definition 1.1).

2.3 oligomer

A substance composed of oligomer
molecules (see Definition 1.2).

Note

An oligomer obtained by
telomerization (see Definition 3.2) is
often termed a **telomer**.

2.4 homopolymer

A polymer ([see Definition 2.2](#)) derived from one species of (real, implicit or hypothetical) monomer ([see Definition 2.1](#)).

Notes

1. Many polymers are made by the mutual reaction of complementary monomers. These monomers can readily be visualized as reacting to give an "implicit monomer", the homopolymerization of which would give the actual product, which can be regarded as a homopolymer. Common examples are poly(ethylene terephthalate) and poly(hexamethylene adipamide).
2. Some polymers are obtained by the chemical modification of other polymers such that the structure of the macromolecules that constitute the resulting polymer can be thought of as having been formed by the homopolymerization of a hypothetical monomer. These polymers can be regarded as homopolymers. Example: poly(vinyl alcohol).

2.5 copolymer

A polymer ([see Definition 2.2](#)) derived from more than one species of monomer ([see Definition 2.1](#)).

Note

Copolymers that are obtained by copolymerization ([see Definition 3.4](#)) of two monomer species are sometimes termed **bipolymers**, those obtained from three monomers **terpolymers**, those obtained from four monomers **quaterpolymers**, etc..

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2.6 [Return to Alphabetical Terms](#) pseudo-copolymer

An irregular polymer ([see Definition 2.16](#)), the molecules of which are derived from only one species of monomer ([see Definition 2.1](#)) but which display a variety of structural features more appropriate for description in copolymer ([see Definition 2.5](#)) terms.

Note

Where appropriate, adjectives specifying the types of *copolymer* may be applied to *pseudo-copolymer*. The term **statistical pseudo-copolymer**, for instance, may be used to describe an irregular polymer in the molecules of which the sequential distribution of configurational units obeys known statistical laws (see Definition 2.9).

2.7 co-oligomer

An oligomer (see Definition 2.3) derived from more than one species of monomer (see Definition 2.1).

2.8 pseudo-co-oligomer

An irregular oligomer (see Definition 2.3), the molecules of which are derived from only one species of monomer (see Definition 2.1) but which display a variety of structural features more appropriate for description in co-oligomer (see Definition 2.7) terms.

2.9 statistical copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) in which the sequential distribution of the monomeric units (see Definition 1.8) obeys known statistical laws.

Note

An example of a statistical copolymer is one consisting of macromolecules in which the sequential distribution of monomeric units follows Markovian statistics.

2.10 random copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) in which the probability of finding a given monomeric unit (see Definition 1.8) at any given site in the chain (see Definition 1.30) is independent of the nature of the adjacent units.

Note

In a random copolymer, the sequence distribution of monomeric units follows Bernoullian statistics.

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alternating copolymer [Return to Alphabetical Terms](#)

A copolymer ([see Definition 2.5](#)) consisting of macromolecules ([see Definition 1.1](#)) comprising two species of monomeric units ([see Definition 1.8](#)) in alternating sequence.

Note

An alternating copolymer may be considered as a homopolymer derived from an implicit or hypothetical monomer; see Note 1 to [Definition 2.4](#).

2.12 periodic copolymer

A copolymer ([see Definition 2.5](#)) consisting of macromolecules ([see Definition 1.1](#)) comprising more than two species of monomeric units ([see Definition 1.8](#)) in regular sequence.

2.13 uniform polymer

monodisperse polymer

A polymer ([see Definition 2.2](#)) composed of molecules uniform with respect to relative molecular mass and constitution.

Notes

1. A polymer comprising a mixture of linear ([see Definition 1.32](#)) and branched ([see Definition 1.33](#)) chains, all of uniform relative molecular mass, is not uniform.
2. A copolymer comprising linear molecules of uniform relative molecular mass and uniform elemental composition but different sequential arrangements of the various types of monomeric units ([see Definition 1.8](#)), is not uniform (e.g., a copolymer comprising molecules with a random arrangement as well as a block arrangement of monomeric units).
3. A polymer uniform with respect only to *either* relative molecular mass *or*

constitution may be termed **uniform**, provided a suitable qualifier is used (e.g., "a polymer uniform with respect to relative molecular mass").

4. The adjectives *monodisperse* and *polydisperse* are deeply rooted in the literature, despite the former being non-descriptive and self-contradictory. They are in common usage and it is recognized that they will continue to be used for some time; nevertheless, more satisfactory terms are clearly desirable. After an extensive search for possible replacements, the terms *uniform* and *non-uniform* have been selected and they are now the preferred adjectives.

2.14 non-uniform polymer

polydisperse polymer

A polymer (see [Definition 2.2](#)) comprising molecules non-uniform with respect to relative molecular mass or constitution or both.

Note

See Notes 3 and 4 to Definition 2.13.

2.15 regular polymer

A polymer composed of regular macromolecules (see [Definition 1.4](#)), regular star macromolecules (see [Definition 1.51](#)), or regular comb macromolecules (see [Definition 1.52](#)).

Note

A polymer consisting of star macromolecules with arms identical with respect to constitution and degree of polymerisation is considered to be regular; see [Note 2 to Definition 1.51](#). Analogously, a polymer consisting of comb macromolecules with the sub-chains between the branch points of the main chain and the terminal sub-chains of the main chain identical with respect to constitution and degree of polymerisation and the side-chains identical with respect to constitution and degree of polymerisation is considered to be regular; see [Note 1 to Definition 1.52](#).

2.16 irregular polymer

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A polymer composed of irregular macromolecules ([see Definition 1.5](#)).

2.17 tactic polymer

A polymer composed of tactic macromolecules ([see Definition 1.21](#)).

2.18 isotactic polymer

A polymer composed of isotactic macromolecules ([see Definition 1.23](#)).

2.19 syndiotactic polymer

A polymer composed of syndiotactic macromolecules ([see Definition 1.24](#)).

2.20 stereoregular polymer

A polymer composed of stereoregular macromolecules ([see Definition 1.22](#)).

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2.21 atactic polymer

A polymer composed of atactic macromolecules ([see Definition 1.25](#)).

2.22 block polymer

A polymer composed of block macromolecules ([see Definition 1.26](#)).

2.23 graft polymer

A polymer composed of graft macromolecules ([see Definition 1.28](#)).

2.24 block copolymer

A copolymer ([see Definition 2.5](#))
that is a block polymer ([see](#)
[Definition 2.22](#)).

Note

In the constituent macromolecules of a block copolymer, adjacent blocks are constitutionally different, i.e., adjacent blocks comprise constitutional units ([see Definition 1.14](#)) derived from different species of monomer ([see Definition 2.1](#)) or from the same species of monomer but with a different composition or sequence distribution of constitutional units.

2.25 graft copolymer

A copolymer ([see Definition 2.5](#))
that is a graft polymer ([see](#)
[Definition 2.23](#)).

Note

In the constituent macromolecules of a graft copolymer, adjacent blocks in the main chain or side-chains, or both, are constitutionally different, i.e., adjacent blocks comprise constitutional units ([see Definition 1.14](#)) derived from different species of monomer ([see Definition 2.1](#)) or from the same species of monomer but with a different composition or sequence distribution of constitutional units.

2.26 [Return to Top](#) stereoblock [Return to Alphabetical Terms](#) polymer

A polymer composed of stereoblock macromolecules ([see Definition 1.29](#)).

2.27 linear polymer

A polymer ([see Definition 2.2](#))
composed of linear macromolecules
([see Definition 1.6](#)).

2.28 linear copolymer

A copolymer ([see Definition 2.5](#))
composed of linear macromolecules
([see Definition 1.6](#)).

2.29 single-strand polymer

A polymer ([see Definition 2.2](#)), the macromolecules ([see Definition 1.1](#)) of which are single-strand macromolecules ([see Definition 1.39](#)).

2.30 double-strand polymer

A polymer ([see Definition 2.2](#)), the macromolecules ([see Definition 1.1](#)) of which are double-strand macromolecules ([see Definition 1.41](#)).

Notes

1. A polymer, the macromolecules of which are spiro macromolecules ([see Definition 1.43](#)), is termed a **spiro polymer**.
2. A polymer, the macromolecules of which are ladder macromolecules ([see Definition 1.45](#)), is termed a **ladder polymer**.

2.31 double-strand copolymer

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A copolymer ([see Definition 2.5](#)), the macromolecules ([see Definition 1.1](#)) of which are double-strand macromolecules ([see Definition 1.41](#)).

2.32 star polymer

A polymer composed of star macromolecules ([see Definition 1.51](#)).

2.33 comb polymer

A polymer composed of comb macromolecules ([see Definition 1.52](#)).

Note

See the Notes to [Definitions 1.52](#) and [2.15](#)

2.34 branched polymer

A polymer ([see Definition 2.2](#)), the molecules of which are branched chains ([see Definition 1.33](#)).

2.35 macromonomer

A polymer composed of macromonomer molecules ([see Definition 1.9](#)).

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2.36 mesogenic monomer

A monomer ([see Definition 2.1](#)) which can impart the properties of liquid crystals to the polymers ([see Definition 2.2](#)) formed by its polymerization ([see Definition 3.1](#)).

2.37 pre-polymer

A polymer or oligomer composed of pre-polymer molecules ([see Definition 1.11](#)).

2.38 polyelectrolyte

A polymer composed of polyelectrolyte molecules ([see Definition 1.65](#)).

2.39 ionomer

A polymer composed of ionomer molecules ([see Definition 1.66](#)).

2.40 polymer blend

A macroscopically homogeneous mixture of two or more different species of polymer ([see Definition 2.2](#)).

Notes

1. In most cases, blends are homogeneous on scales smaller than several times visual optical wavelengths.
2. For polymer blends, no account is taken of the miscibility or immiscibility of the constituent polymers, i.e., no assumption is made regarding the number of phases present.
3. The use of the term *polymer alloy* for a

polymer blend is discouraged.

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2.41 network polymer

polymer network

A polymer composed of one or more networks ([see Definition 1.58](#)).

2.42 semi-interpenetrating polymer network (SIPN)

A polymer ([see Definition 2.2](#)) comprising one or more networks ([see Definition 1.58](#)) and one or more linear ([see Definition 1.32](#)) or branched ([see Definition 1.33](#)) polymer(s) characterized by the penetration on a molecular scale of at least one of the networks by at least some of the linear or branched macromolecules.

Note

Semi-interpenetrating polymer networks are distinguished from interpenetrating polymer networks because the constituent linear or branched polymers can, in principle, be separated from the constituent polymer network(s) without breaking chemical bonds; they are polymer blends.

2.43 interpenetrating polymer network (IPN)

A polymer ([see Definition 2.2](#)) comprising two or more networks ([see Definition 1.58](#)) which are at least partially interlaced on a molecular scale but not covalently bonded to each other and cannot be separated unless chemical bonds are broken.

Note

A mixture of two or more pre-formed polymer networks is not an IPN.

2.44 polymer-polymer complex

A complex, at least two components

of which are different polymers ([see Definition 2.2](#)).

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